Supporting Information: "High-speed, phase-dominant spatial light modulation with silicon-based active resonant antennas"

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In this Supporting Information, we present additional information on

Figure S1 Schematic of experimental setup,

Figure S2 Measured reflectivity spectra for phase measurements,

Figure S3 Simulated response times in temperature modulation, and

Figure S4 Simulated phased array beam deflection.

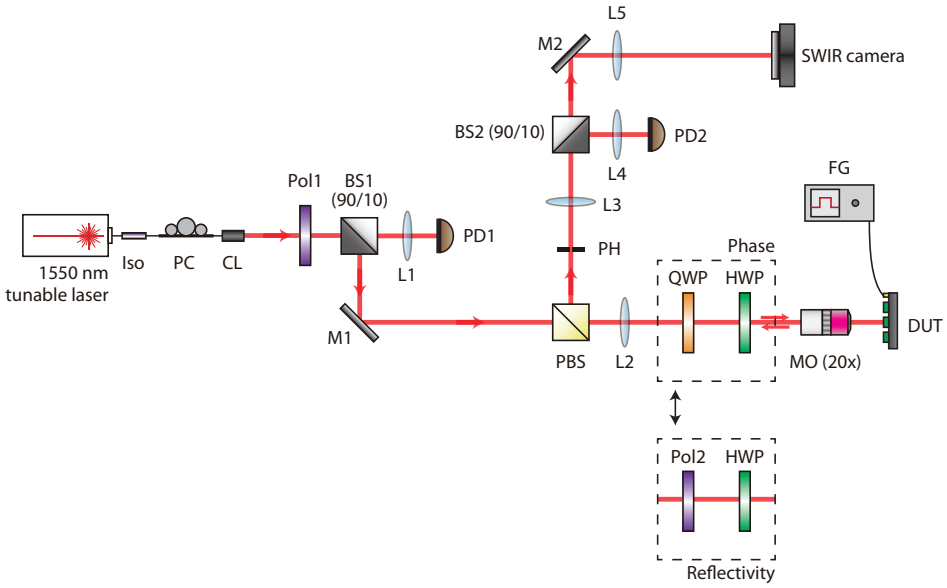

Figure S1: Experimental setup. A continuous-wave laser light emitted from a tunable external cavity laser diode was used as a light source for the measurements. After transmitting through the PBS, the laser beam was demagnified by a lens (L2, focal length: 200 mm) and a 20× microscope objective (MO), resulting in a Gaussian beam waist of 75 µm on the object plane. The reflected light was then imaged by the same lenses onto a pinhole (PH) with a diameter of 400 µm to select the region of interest with a corresponding diameter of 20 µm in the object plane. After the PH, the intensity was measured by focusing the light onto PD2 using a lens pair of L3 and L4, while the device image was monitored by a SWIR camera. The image was created with the L3 and L5 lens pair. For the reflectivity measurement, a polarizer and a HWP were inserted in the path, where the angle of the polarizer was set to 45° with respect to the axes of the PBS. For the phase extraction measurement, a QWP was inserted in place of the polarizer in order to make the incident polarization state elliptical. Iso: optical isolator. PC: polarization controller. CL: collimation lens. Pol: polarizer. BS: beamsplitter. L: lens. PD: photodetector. M: mirror. PBS: polarizing beamsplitter. QWP: quarter waveplate. HWP: half waveplate. MO: microscope objective. DUT: device under test. FG: function generator. PH: pinhole.

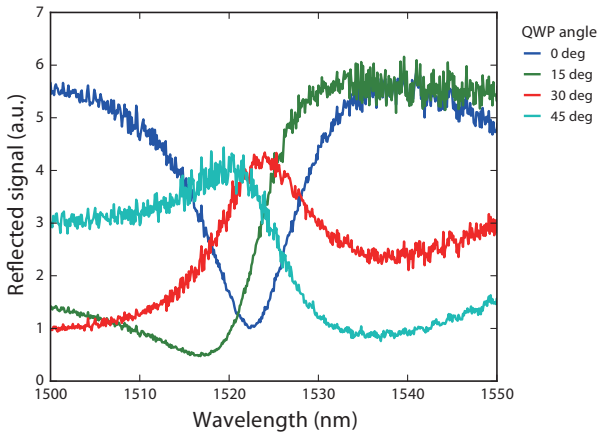

Figure S2: Measured reflectivity spectra for different QWP angles in a cross-polarized setup. These data were used to fit the model to extract the phase curve in Fig. 2(b).

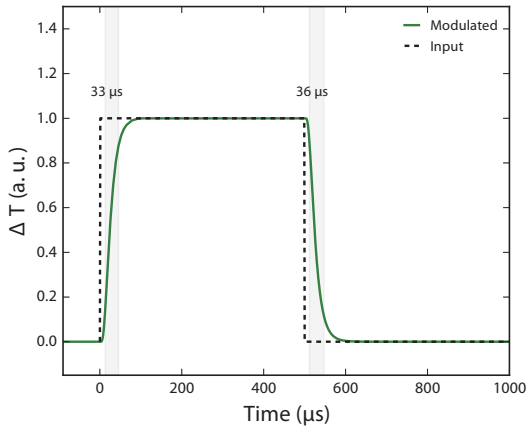

Figure S3: Simulated response times in temperature modulation. The time-dependent heat transfer simulations were performed by FEM. The rise and fall response times were found 33 µs and 36 µs, respectively, in fair agreement with measured values. The difference between the simulation and the measurement should be attributed to the difference between thermal conductivities used in simulation and the actual values. The response time here is defined as the time duration by which the temperature rises (or falls) from 10% to 90% (or vice versa) of the steady-state when an input signal modulates the microheater.

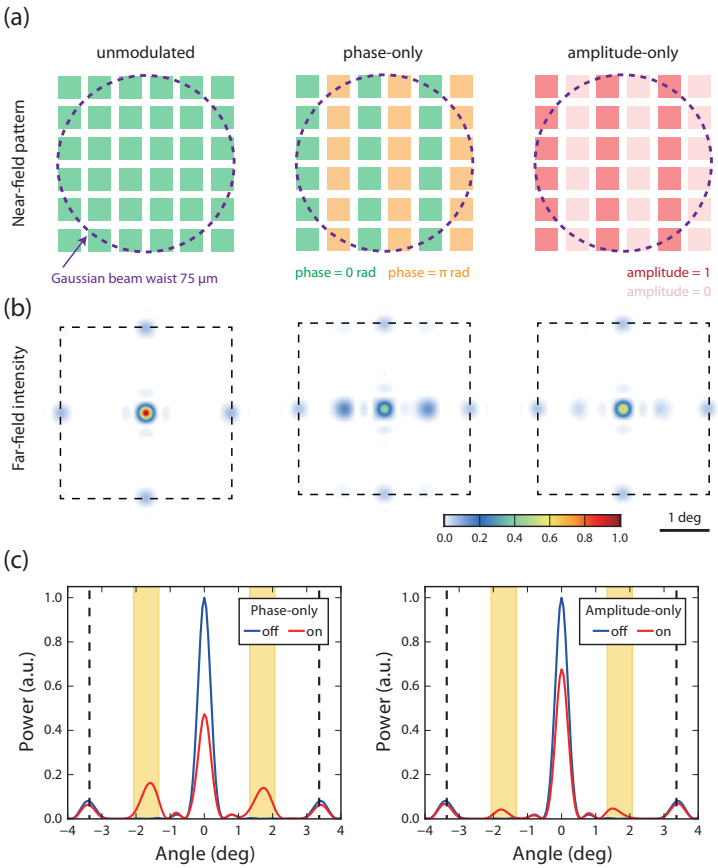

Figure S4: Simulated phased array beam deflection. (a) Simulated near-field phase and amplitude profiles in cases of amplitude-only and phase-only modulations. An incident Gaussian beam profile with a beam waist of 75 μm was used. (b) Simulated far-field patterns. The dashed box indicates the ± 1st order diffraction angles imposed by the pixel pitch. (c) Corresponding 1D profiles of the simulated far-field patterns along the deflection direction, showing that phase modulation can perform beam deflection with a higher efficiency. This also confirms that the silicon active antennas used in the experiments do phase-dominant modulation. The deflected beam appeared at the angles $\theta = \pm\theta_{\max} = \pm 1.7°$ as denoted by the yellow shades including the Gaussian divergence half angle of $0.37°$. The dashed line corresponds to the angles of the ± 1st diffraction orders resulting from the pixel pitch.